DOUBLE TRACK TRUNION BASCULE BRIDGE FOR ELECTRIC CARS

BY
P. M. LEICHENKO
E. C. HOLDEN
M. L. LOWENBERG

ARMOUR INSTITUTE OF TECHNOLOGY

1912

THESIS

A SINGLE LEAF, DOUBLE TRACK TRUNION BASCULE BRIDGE FOR INTERURBAN ELECTRIC CARS.

Presented by

P. M. Leichenko.
E. C. Holden.
M. L. Lorenberg.

to the

PRESIDENT AND FACULTY

of the

ARMOUR INSTITUTE OF TECHNOLOGY

for the degree of

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

having completed the prescribed course

of study in

CIVIL ENGINEERING

1912.

Approved by Alfred E. Phillips
Prof. Civil Engineering
F. M. Raymond
Dean of Eng. Studies
L. C. Morrin
Dean of Coll. Studies

THESIS.

Design and General Drawings

of a

Single Leaf - Double Track Trunion

Bascule Bridge for Interurban Cars.

Length of Span, 110 ft. from pin to free end.

Circular Segment, 35 ft. radius.

Clear Span, 75 ft.

5 Panels at 20 ft.

1 Panel at 10 ft.

Height of truss - at free end - 25 ft.

Height of truss - at pin end - 35 ft.

Width - 27 ft. c to c of trusses.

Sidewalks - 5 ft. wide.

Overall width - 39 ft.

LOADING.

Cooper's Class B. Suburban or Interurban Bridges.

For Trusses - Loads as per Table A.

Live Panel Load 48000 lbs.

SPECIFICATIONS.

American Railway Engineering & Maintenance of Way Association.

STRINGERS.

The timbers and flooring were designed first and the weight per stringer calculated.

INTERMEDIATE STRINGERS.

Max. L.L. Bending Moment = 466200 in.lbs.

Max. D.L. " " = 53300

Total " " = 519.500 in.lbs.

$M/S = I/C = \frac{519500}{16000} = 32.3$

Use 12" @ 31.50# I-beams with I/C = 36

TROLLEY STRINGERS.

Max. L.L. Bending Moment = 810,000

" D.L. " " = 120,450

L.L. Impact = 760,000

Total = 1.690,450 inch.lbs.

D.L. End Shear = 2150

L.L. " " = 9000

Impact = 8450

Total=19600 #

Section used - 4 angles 4"x 4" x $\frac{1}{2}$"

1 web. plate 20" x 3/8"

FLOOR BEAM.

Max. D.L. Bending Moment = 1,225,000

" L.L. " " = 3,756,000

Impact = 3,440,200

Total = 8,421,200 inch.lbs.

FLOOR BEAM (cont.)

D.L. End Shear = 14280

L.L. " " = 45000

Impact = 41500

Total = 100780#

Section used 4 angles 6" x 6" x 13/16"

1 web plate 36" x 3/8"

Bridge Closed.

DEAD LOAD STRESSES - COEFFICIENTS.

The counter weight was considered as balancing the D.L. of the bridge to give zero reaction at the free end with bridge unloaded. A D.L. of 1 kip was assumed at each panel point and the D.L. stresses figured analytically, considering the moving leaf as a cantelever. These stresses were used as a table of coefficients when the correct D.L. was figured. See Table 1.

LIVE LOAD STRESSES - COEFFICIENTS.

The L.L. stresses were figured with a L.L. of 1 kip moving from the free end to the pin. The L.L. stresses were also figured with the L.L. moving from the pin to the free end. See Table 1.

THE ABUTMENTS.

The piers and the abutments were designed considering the weight of the bridge, water pressure, and earth pressure. The resultant of these forces fell within the middle third of bases.

TABLE 1.

Dead Load, Live Load, and Wind Load Coefficients for a Load of 1 Kip at Panel Points

Member	Bridge Closed: Dead Load	Live Load Moving from Free End L to e	Live Load Moving to Free End e to L	Wind Load in Chords	Bridge Open: Dead Load	Wind Load	# Final Weight
KL	+.640	-1.050	-2.910		+.166	±.65	1920
kL	-.400			±8.150	-.413	±.45	1400
Kk	-.500	+.818	+2.270		-.166	±.50	1000
HK	+.400				-.082	±.45	800
Hk	+1.930	+.233	-1.860		+.503	±2.00	1600
hk	-1.600			±7.800	-1.530	±1.70	1400
Hh	-1.500	-.182	+1.458		-.503	±1.50	1000
GH	+1.600				-.005	±1.70	800
gh	-3.600			±6.600	-2.620	±3.20	2588
Gg	-1.730	-.545	+.408		-.830	±3.70	1000
Fg	+3.300	+1.890	-.220		+1.280	±1.70	1775
gf	-5.500			±5.200	-4.000	±3.30	2588
FG	+3.700				+.240	±5.50	2185
Ff	-2.335	-1.330	+.155		-1.080	±3.80	1450
ef	-7.450			±3.260	-5.350	±2.30	3168
Ef	+3.890	+2.580	-.043		+1.530	±7.50	2340
Ee	+1.000	+1.000	+1.000		+.190	±3.80	1675
FE	+5.590				+.680	±1.00	2185
ec	-7.450				-6.010	±5.70	1584
Ec	-5.300	-2.87	-.955		-1.910	±7.50	3500
ED	+8.960				+1.660	±5.20	1648
Dc	-4.100	For chord			-.710	±9.00	1750
CD	+8.960	stresses			+1.330	±4.00	1990
Cc	-9.100	$W/W = 48/28$			-.040	±9.00	1150
cb	-2.720	= 1.714			+9.380	±3.00	1360
CB	+5.600				+1.420		1990
BA	+6.750				+2.318		1990
Cb	-6.500				-3.400		1680
Bb	-8.830				-4.580		1890
Ab	-1.47				+5.450		1360
Gh	+3.22	+.7	-.525		+1.000		1600
							54366

LATERAL SYSTEMS.

The stresses in the lower chord lateral bracing were figured from a W.L. per panel of 8800#. The train load - cars end to end - = 2400# per lin. ft. of one track. Lateral force on loaded chord = 200# per lin. ft.+ 10% of train load on one track

= 200+240 = 440# per lin.ft. moving load

20 x 440 = 8800# W.P.L.

The stresses in the upper lateral bracing were figured from a moving load of 200# per lin.ft. W.P.L. = 4000#.

The lateral systems were figured as cantelever trusses.

Bridge Open.

DEAD LOAD STRESSES - COEFFICIENTS.

The bridge was considered raised at an angle of 79° with the horizontal and the D.L. stresses scaled graphically, using one kip at the panel points. The stresses were tabulated as coefficients.

WIND LOAD.

A wind load of 25# per sq.ft. was considered as acting perpendicular to the floor surface. The W.L. stresses from top of bridge perpendicular to floor

have the same coefficients as D.L. stresses for bridge closed, assuming W.L. of 1 kip per panel. W.L. Stresses, with wind from bottom of bridge perpendicular to floor, were scaled graphically. See Table 1, bridge open.

Approximate Stresses.

The D.L. per panel of the North Avenue Bridge and the Archer Avenue Bridge was obtained and used as a basis for assuming the D.L. per panel of this bridge.

A D.L. per panel of 19 kips was assumed and multiplied by the coefficients to obtain the approximate D.L. stresses. A table was made of the L.L., D.L., and W.L. Stresses with bridge open and closed, and the maximum + and − stresses figured for each member according to specifications for an alternating stress.

Next the members were designed and their total weight computed + 30% for details. The weight of flooring and laterals was added in and the total was found to be 27.5 kips D.L. per panel.

Corrected Stresses.

The D.P.L. was assumed as 28 kips and Table 2 made of all the stresses, and the members were redesigned.

TOTAL WEIGHT OF BRIDGE.

Weight of Members in Table 1.

9.8	kips	per	panel	- truss
17.5	"	"	"	- floor load
0.7	"	"	"	- laterals
28.0	"	"	"	- D.L. Maximum

COUNTER WEIGHT.

The center of gravity of the bridge was located and the center of gravity of the counter weight was placed in line with it through the pin.

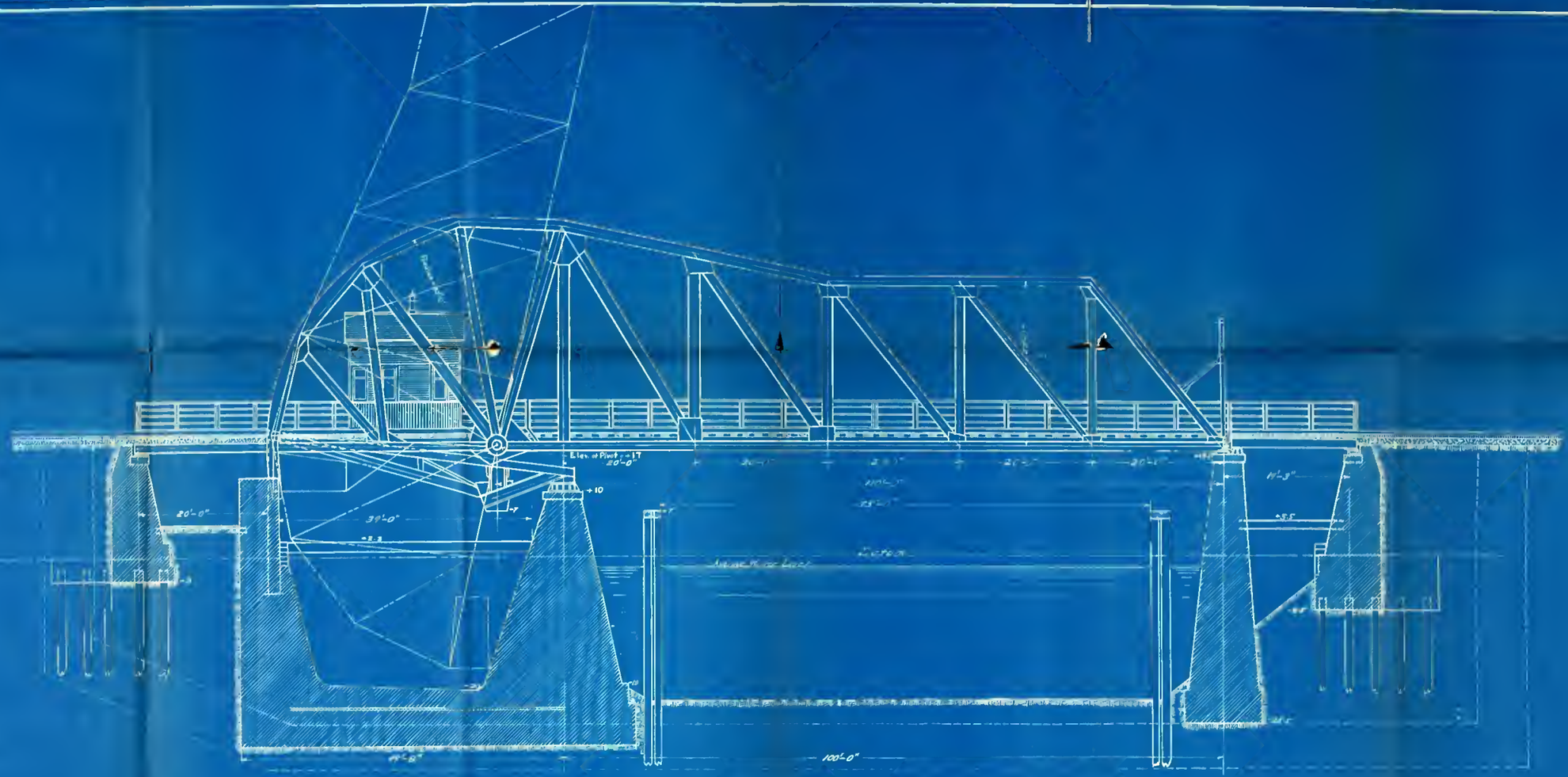
The sides of the counterweight box were designed as plate girders to carry the weight with bridge closed. The bottom of the box was designed as a plate girder to take the weight with bridge open.

PIVOT TRUSS.

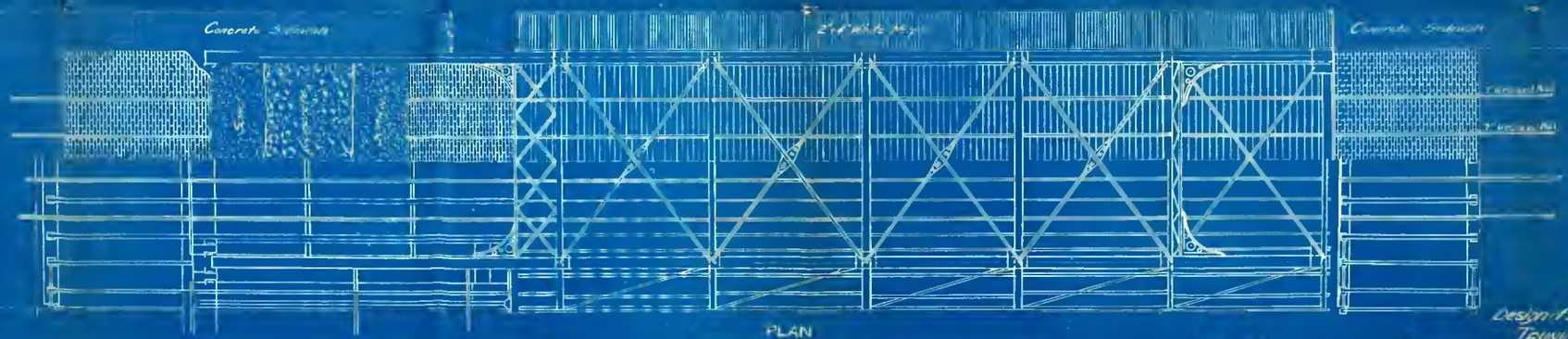
The pivot trusses were designed to carry the weight of the bridge to the abutments and to support the roadway as far as the movable leaf.

TABLE 2. Final Stresses

Member	Bridge Closed L.L.#	D.L.#	W.L.#	Total#	Bridge Open D.L.#	W.L.#	Total #	Maximum#
LK	+50400 -139,680	+17,800		+93400 -152,980	+4650	±6500	+11,150 -4,000	+93400 -152980
Hk	+11185 -89,280	+54,100		+70880 -58700	+14000	±20000	+34,000 -11,000	+70880 -58700
kL	-19200	-11,200	±81500	+81500 -111900	-11580	±4500	-16,080	+81500 -111900
Kk	+39260 +108960	-14,000		-147900 +144270	-4650	±5000	-9,650	-14700 +99000
hk	-76,750	-44,700	±78000	-129250	-42800	±17000	-22000	-129250
HK	+19200	+11200		+30,400	-2290	±4500	-7000	-7000 +30400
GH	+76,750	+44,700		+121450	-140	±17000	±17000	-17000 +121450
Hh	-8700 +69984	-42,000		-55000 +46300	-14000	±15000	-29000	-65000 +46300
gh	-173000	-101500	±66000	-340500	-73400	±37000	-110400	-340500
Gh	+38,600 -25,200	+90100		+123700	+2800	±32000	+60000	-32000 +123700
Gg	+19,500 -26,160	-48500		-74660	-23200	±17000	-40200	-74660
fg	-263,800	-154000	±52000	-469800	-112000	±55000	-167000	-469800
Fg	+90820	+92500		+183320	+35800	±33000	+68800	-12000 +183320
FG	+178,000	+103500		+281500	+70000	±38000	+108000	+281500
Ff	+7,400 -63,840	-65,400		-129240	-30200	±23000	-53200	-129240
ef	-356,800	-204,000	±32600	-593400	-149500	±75000	-224500	-593400
Ef	+123,840	+109,000		+232840	+42800	±38000	+80800	+232840
EF	+268000	+156,000		+424000	+19000	±57000	+76000	-45000 +424000
Ee	+48000	+28000		+76000	+5320	±10000	+15000	-76000
ce	-356800	-204,000		-560800	-168000	±75000	-243000	-560800
DE		+250500			+46500	±90000	+136500	-60000 +250500
CD		+250,500			+37300	±90000	+127300	-65000 +250500
BC		+156500			+39800		+39800	+156500
BA		+189,000			+65000		+65,000	+189000
Ec	-137,760	-148,200		-285960	-53500	±52000	-105500	-285960
Dc		-114,800			-19890	±40000	-59,890	-114800
Cc		-255,000			-1112	±30000	-31,112	-255000
Cb		-182,000			-95400		-95400	-182000
Bb		-247000			-128200		-128200	-247000
bc		-76200			+262000		+262000	-76200 +262000
Ab		-41200			+152500		+152500	-41200 +152500



LONGITUDINAL SECTION



PLAN

THESIS

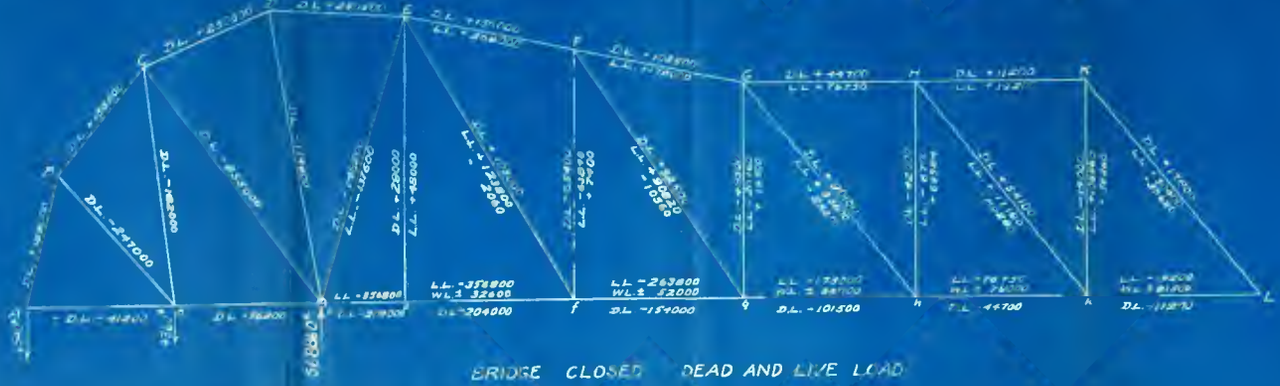
Design of a Single Leaf Double Track Trunion Bascule Bridge for Interurban Electric Ry. System

by J. Landman, E. Holden & M. Lowenstein

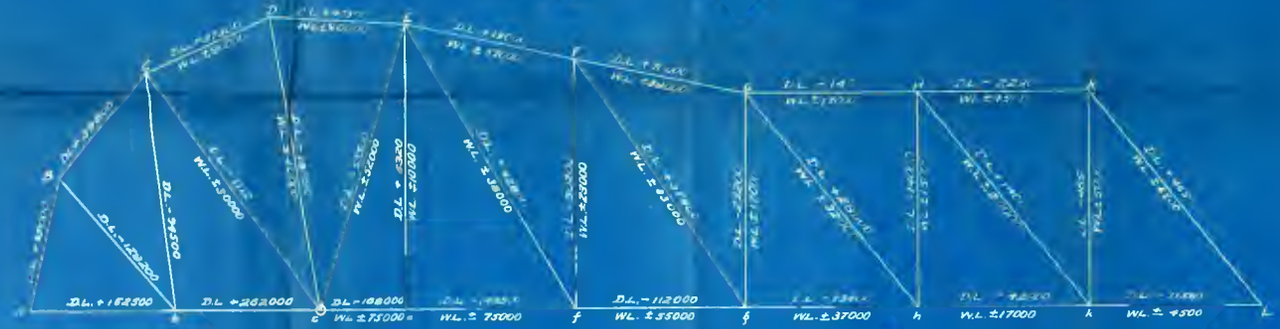
Plan & Elevation

1 of 6 sheets

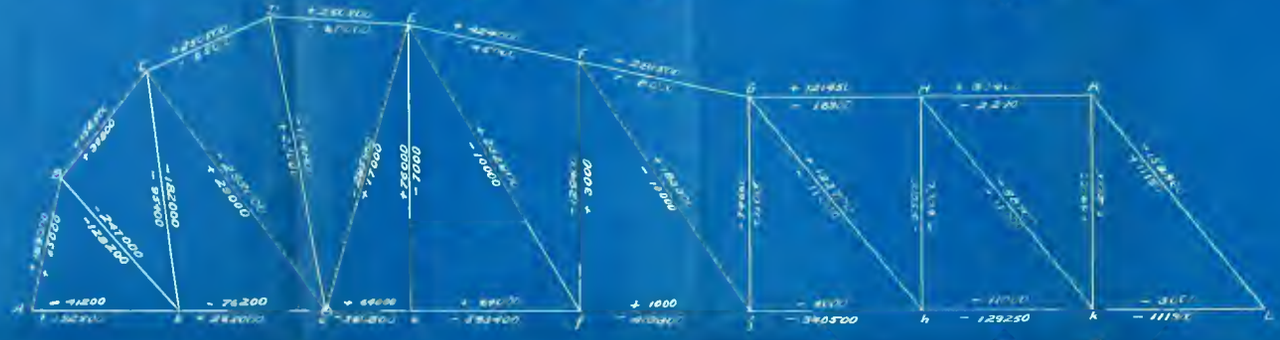
May 1912



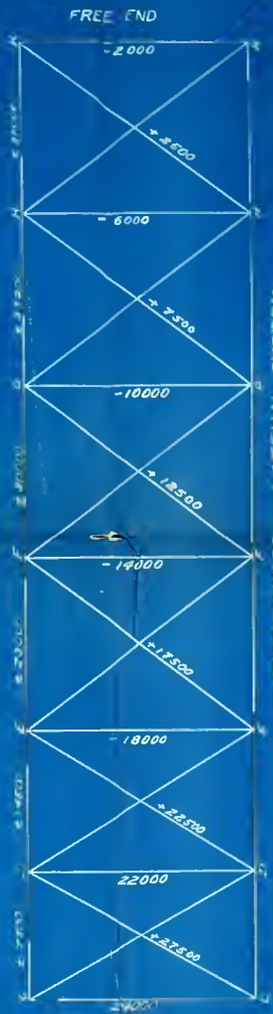
BRIDGE CLOSED DEAD AND LIVE LOAD



BRIDGE OPEN DEAD AND WIND LOAD



MAXIMUM AND MINIMUM STRESSES



PIVOT TRUSS

Note :-
+ Denotes Tension
− Denotes Compression

LIVE LOAD = 72000 # per Panel on Truss
DEAD = 28000 #
Portion chord — WIND = 8000 #
TOP = 4000 #

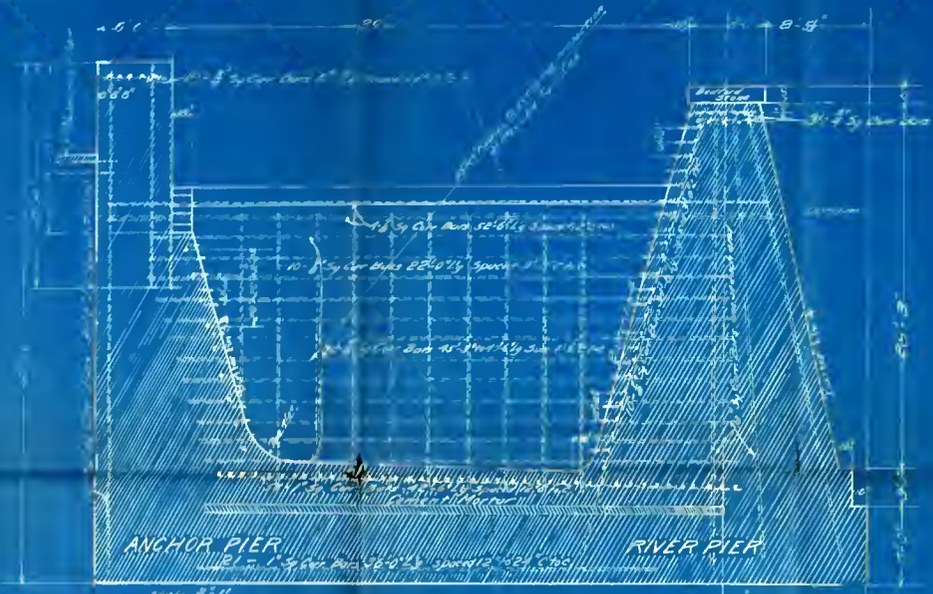
THESIS

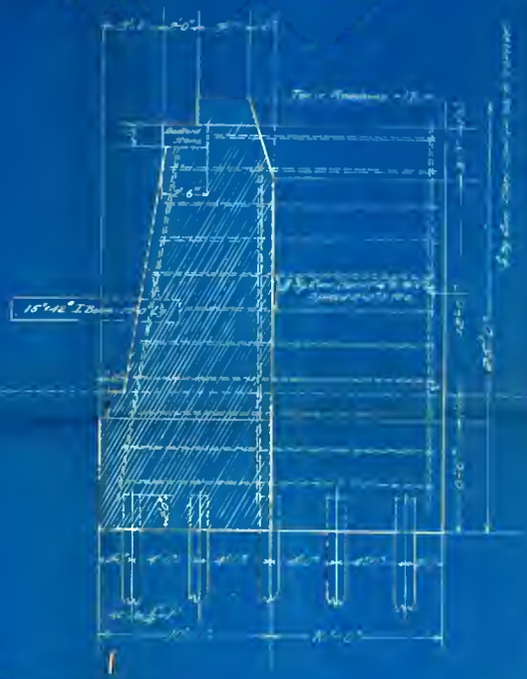
Design of a Single Leaf Double Track Trunion Bascule Bridge for Interurban Electric Ry Service by P Leschenko, E Hollen & N Loewenberg

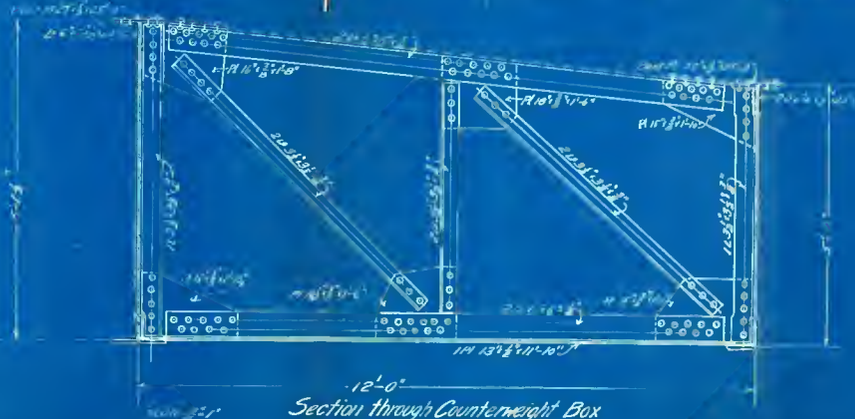
Stress Sheet

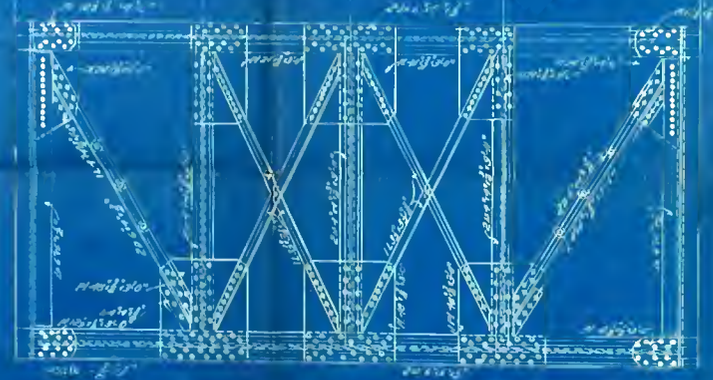
2 of 6 Scale 1"=1' #

May 1912









THESIS

Design of a Single Leaf Double Track Trunion Bascule Bridge

for Interurban Electric Ry. System

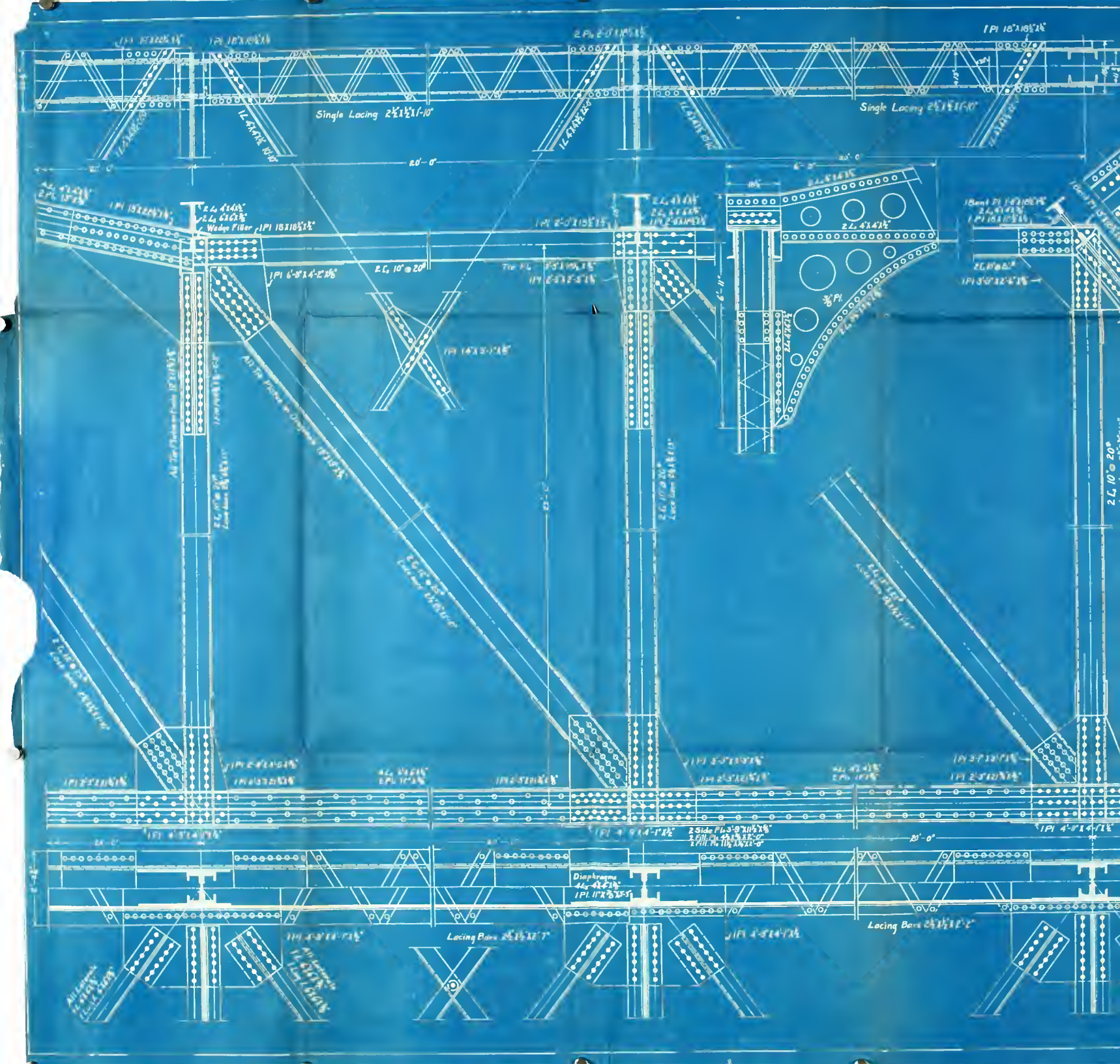
by P. Leichenko, E. Holden & M. Lemnitzer

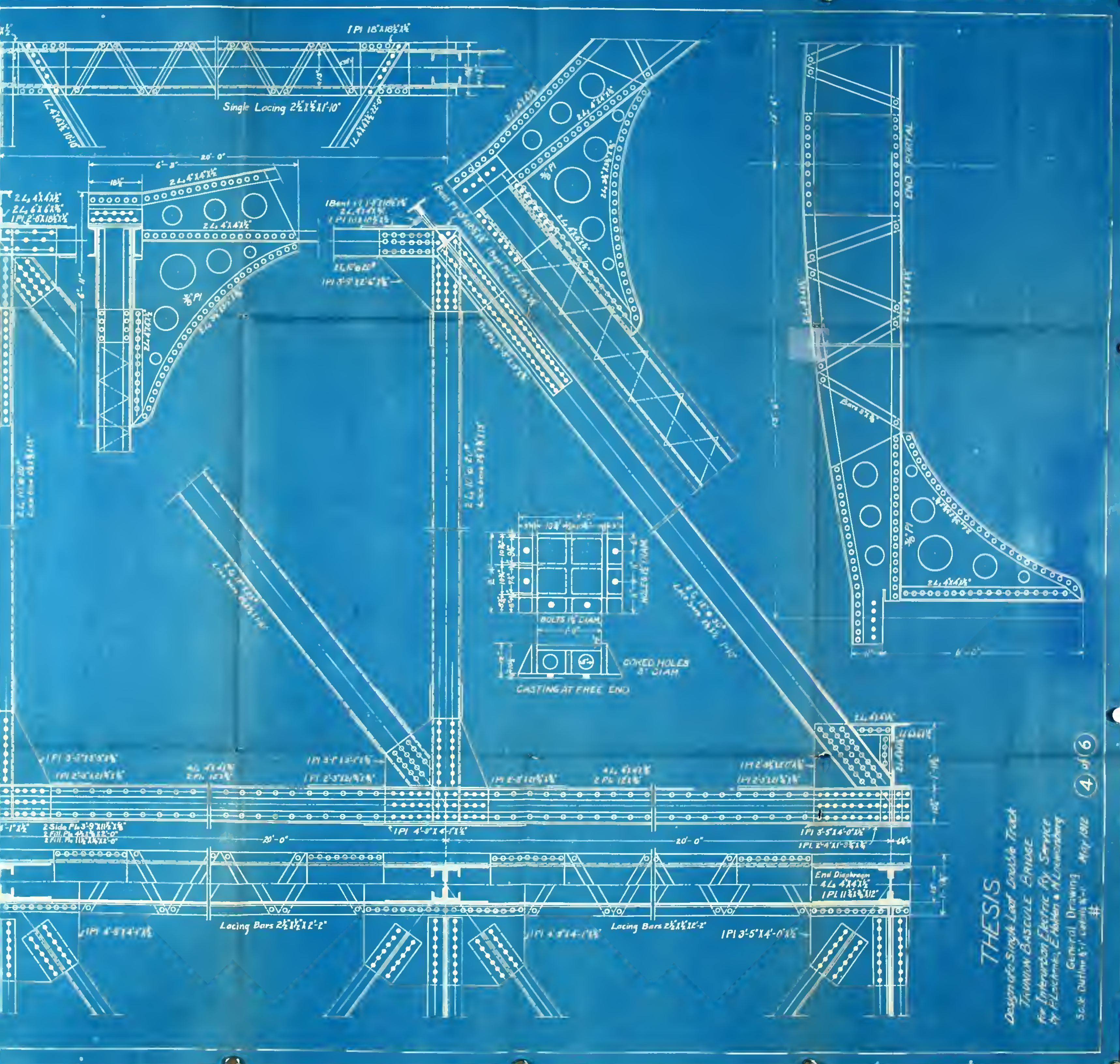
PIERS & COUNTERWEIGHT BOX DETAILS

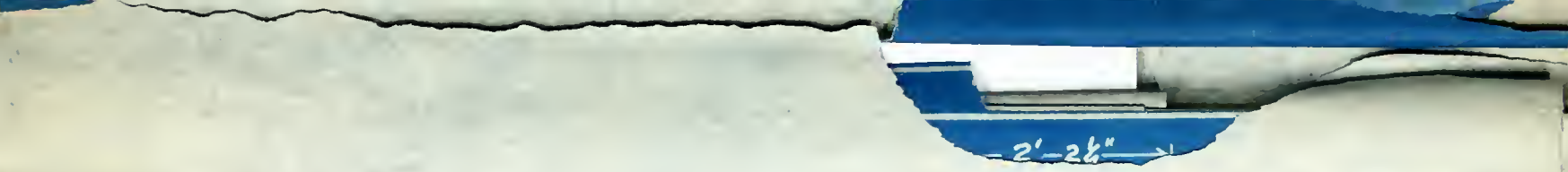
scale as indicated

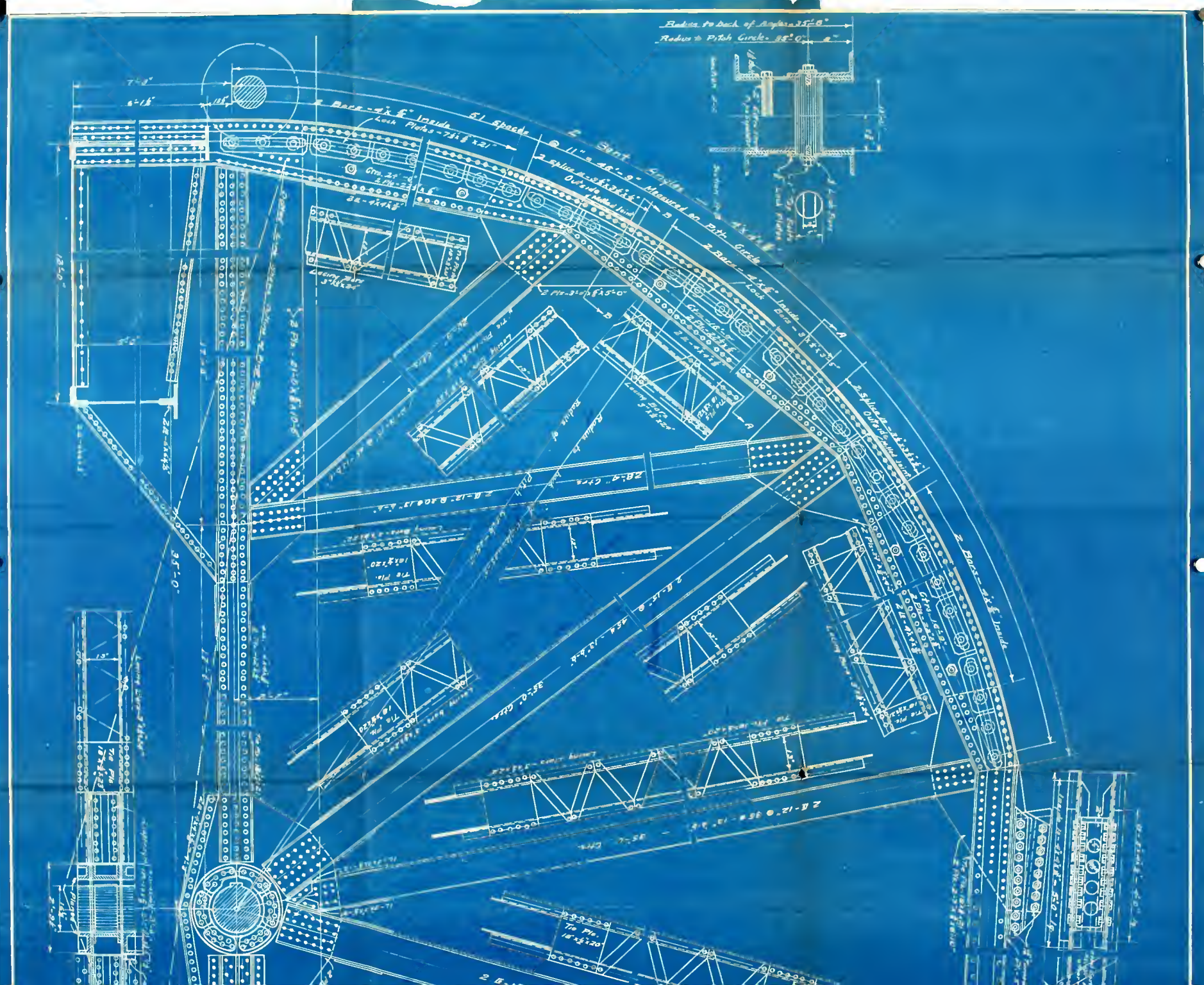
N. y. U. C. E.

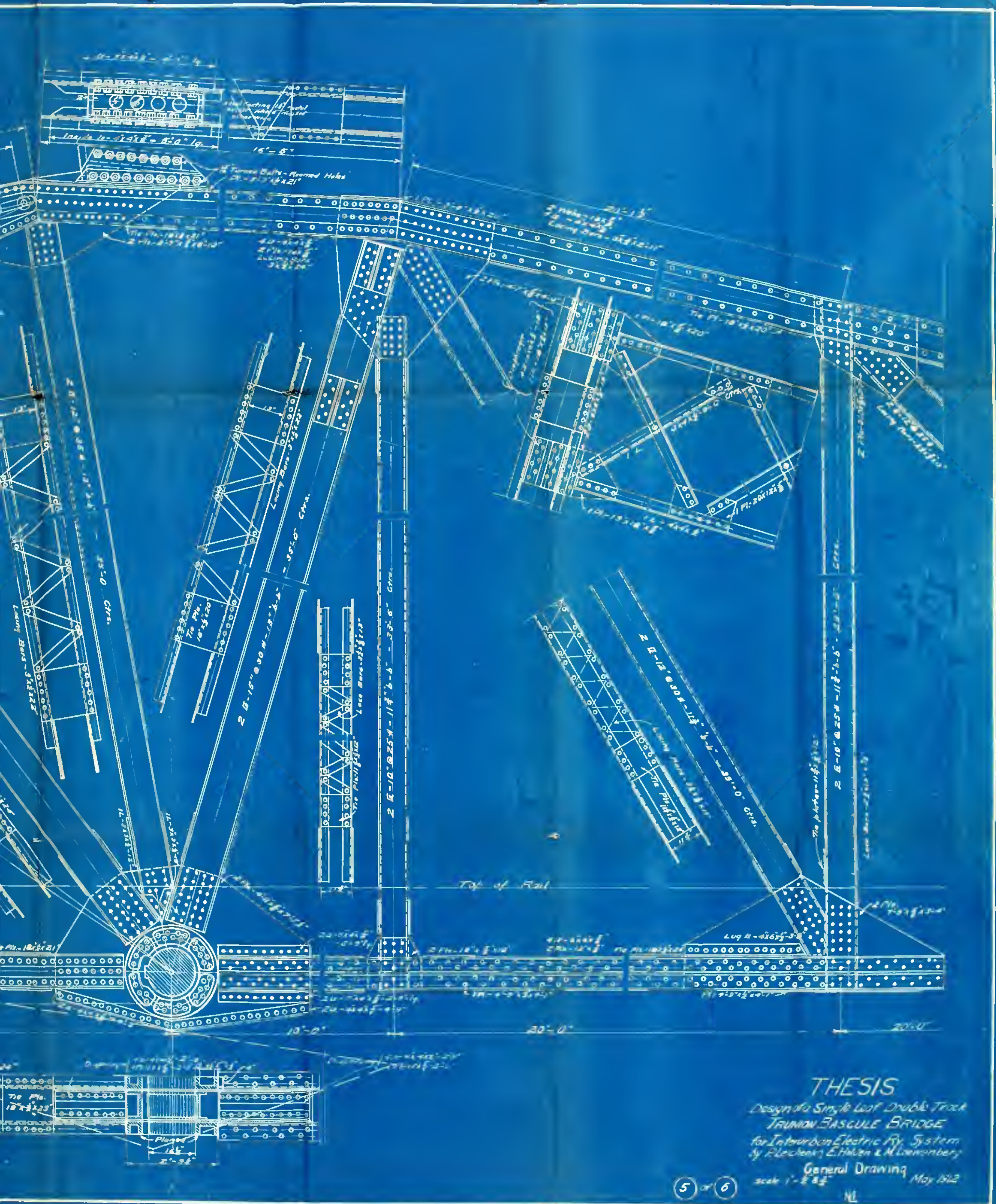
3 or 6


Single Lacing
20'-0"
Wedge Filler
Tie Pl.
Diaphragm
Lacing Bars
20'-0"

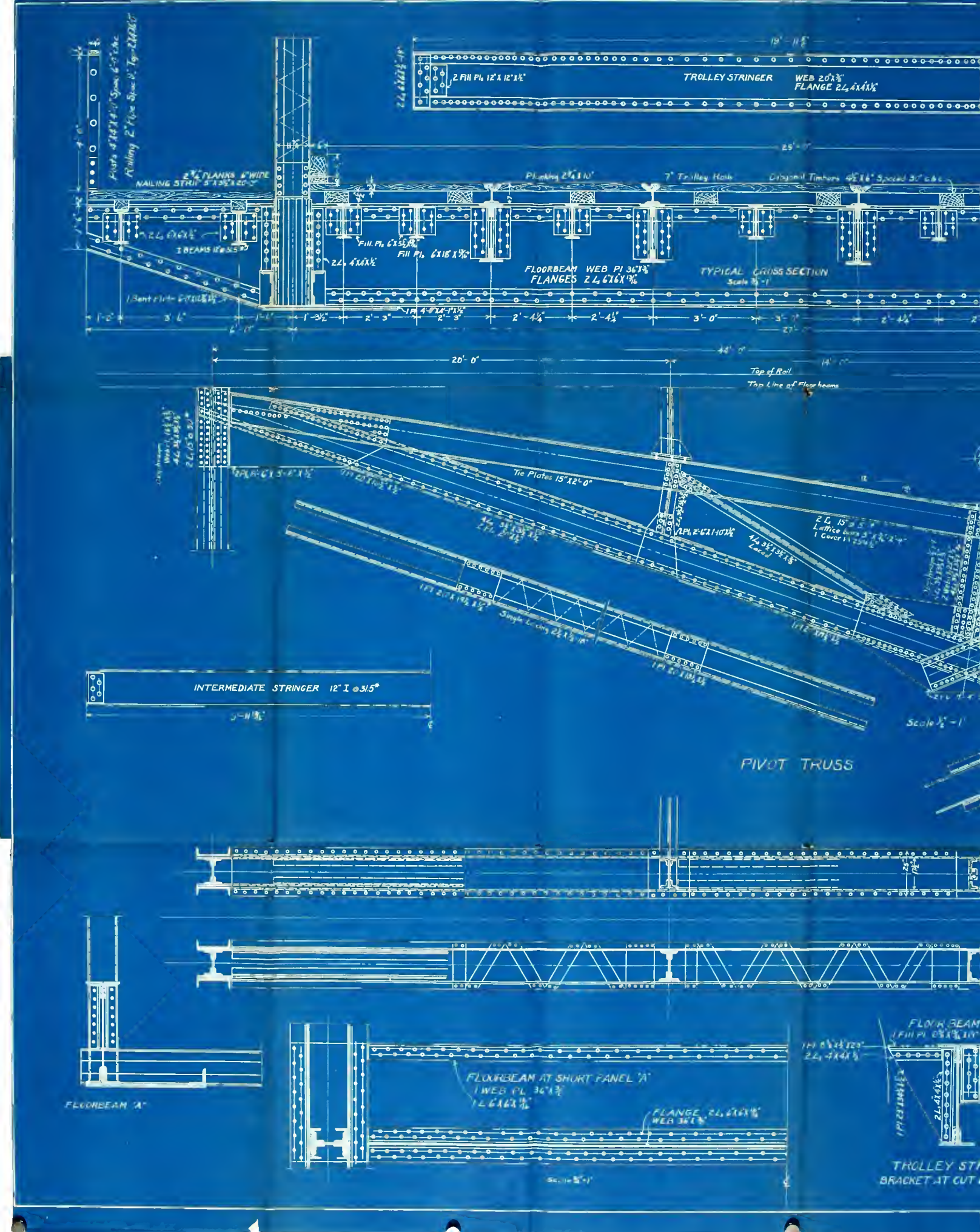

Single Lacing 2½"x⅜"x1'-10"
20'-0"
End Portal
Castings at Free End
Cored Holes 5" Diam
Bolts 1⅛" Diam
End Diaphragm
Lacing Bars 2½"x½"x2'-2"
THESIS
Design of a Single Leaf Double Track
Trunnion Bascule Bridge
for Interurban Electric Ry Service
by P. Lochmann, E. Mohlen & H. Luckenmeyer
General Drawing
May 1912
4 of 6

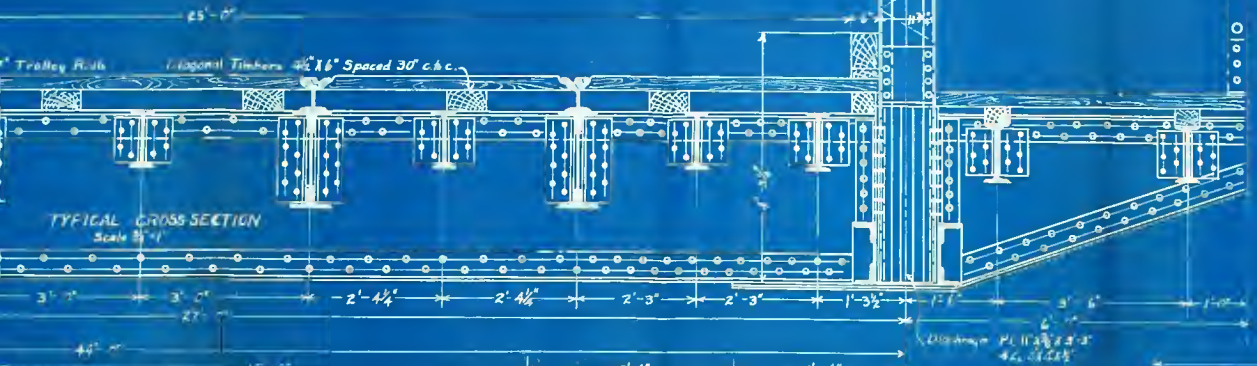

2'-2½"


Radius to Back of Angles 35'-8"
Radius to Pitch Circle 35'-0"
2 Bars - 4"x1" Inside
51 Spaces @ 11" = 46'-9" Measured on Pitch Circle
2 Splices - 5"x3"x1/2"
Outside Radial Joint
2 Bars - 4"x1" Inside
Lock Plates - 7"x1"x21"
Lacing Bars 3"x1/4"
2 Splices - 5"x3"x1/2"
Outside Radial Joint
2 Bars - 4"x1" Inside
2 Pls - 3'-1"x1"x5'-0"
2 Pls - 3'-1"x1"x5'-0"
28'-4" Crs.
35'-0" Crs.
35'-0" Crs.
35'-0"

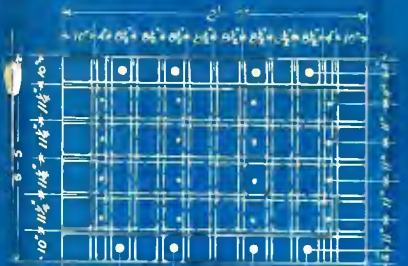


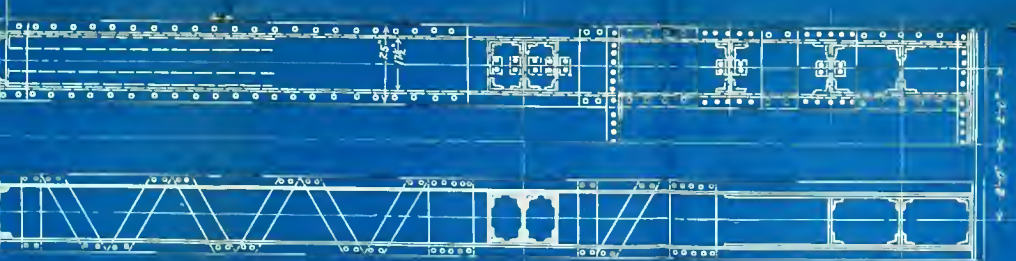
THESIS
Design of a Single Leaf Double Track
TRUNNION BASCULE BRIDGE
for Interurban Electric Ry. System
General Drawing
May 1912
5 of 6
Top of Rail
10'-0"
20'-0"
16'-5"
2 [-15" @ 30# - 13" b-b - 35'-0" Ctrs.
2 [-10" @ 25# - 11⅞" b-b - 32'-6" Ctrs.
2 [-12" @ 30# - 11⅞" b-b - 35'-0" Ctrs.
35'-0" Ctrs.
Lacing Bars
Tie Pls.

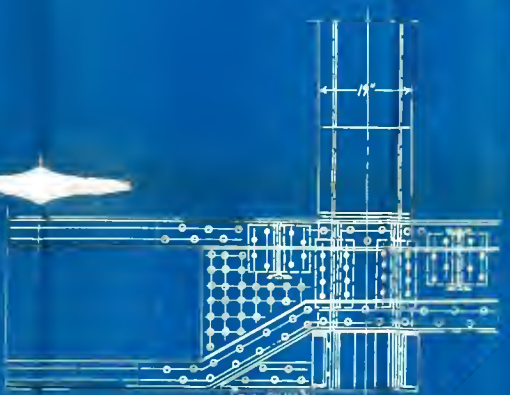

TROLLEY STRINGER
WEB 20"x⅜"
FLANGE 2 L 4"x4"x½"
2 Fill Pls 12"x 12"x½"
2¾" PLANKS 6" WIDE
NAILING STRIP 5"x3½"x20'-0"
Posts 4"x8" 4'-0" Spaces 6'-2" c.to c.
Railing 2" Pipe Spaced 2" Top 2'-8½" A.R.
Planking 2¾" x 11"
7" Trolley Hole
Diagonal Timbers 4½"x 6" Spaced 3'-0" c.to c.
2 L 6"x6"x⅝"
I BEAMS 12" @ 31.5#
2 L 4"x4"x½"
Fill Pl, 6"x 5/16"
Fill Pl, 6"x 18"x ⅜"
FLOORBEAM WEB Pl 36"x⅜"
FLANGES 2 L 6"x6"x⅜"
TYPICAL CROSS SECTION
Scale ½"=1'
1 Bent Plate 6"x12"x⅜"
1 Pl 4'-7¼"x 1'-1½"
25'-0"
20'-0"
Top of Rail
Top Line of Floor beams
Tie Plates 15"x12"x 0"
2 L 15" @ 33.9#
Lattice bars 3"x⅜"x 2'-0"
1 Cover Pl 12"x⅜"
1 Pl, 2'-6"x 1'-10½"
4 L 3½"x3½"x⅜"
Laced
Single Lacing 2½"x⅜" @
INTERMEDIATE STRINGER 12" I @ 31.5#
Scale ½"=1'
PIVOT TRUSS
FLOORBEAM "A"
FLOORBEAM AT SHORT PANEL "A"
1 WEB PL 36"x⅜"
2 L 6"x6"x⅜"
FLANGE 2 L 6"x6"x⅜"
WEB 36"x⅜"
1 Pl 8½"x⅝"x 12'-0"
2 L 4"x4"x⅝"
FLOOR BEAM
1 Fill Pl 6"x⅜"x 1'-0"
2 L 4"x4"x⅝"
TROLLEY ST
BRACKET AT CUT



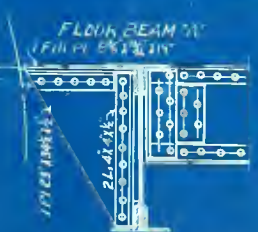
PIVOT TRUSS







END FLOORBEAM CONNECTION



TROLLEY STRINGER
BRACKET AT CUT IN FLOOR

INTERMEDIATE STRINGER
BRACKET AT CUT IN FLOOR

THESIS

Design of a Single Leaf Double Track
TRUNION BASCULE BRIDGE
for Interurban Electric Ry. Service

by P. Lerchenko, E. Holden & M. Lewenberg

Pivot Truss & Details
Scale ¾"=1', ⅜"=1"
May 1912